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(54) Title: MOTOR FUEL FOR DIESEL, GAS-TURBINE AND TURBOJET ENGINES, COMPRISING AT LEAST FOUR DIFFERENT OXYGEN-CONTAINING FUNCTIONAL GROUPS SELECTED FROM ALCOHOL, ETHER, ALDEHYDE, KETONE, ESTER, INORGANIC ESTER, ACETAL, EPOXIDE AND PEROXIDE

(57) Abstract: The invention relates to a motor fuel for diesel, gas-turbine and jet engines, including standard engines, comprising a mixture of organic compounds containing bound oxygen, and optionally a hydrocarbon fraction. The fuel is a stable homogeneous liquid at atmospheric pressure and normal ambient temperature and achieves a reduction of harmful pollutants in the exhaust emissions of the engines. Organic compounds containing oxygen, which compounds contributes to at least a total of four different oxygen-containing functional groups, are employed in the fuel composition. The total concentration of organic compounds containing bound oxygen in the fuel composition generally varies from 5 % and to 100 % of the total volume of the fuel composition, and the concentration of the hydrocarbon compounds varies, correspondingly, from 95 % to 0 % of the total volume of the fuel composition.

MOTOR FUEL FOR DIESEL, GAS-TURBINE AND TURBOJET ENGINES, COMPRISING AT LEAST FOUR DIFFERENT OXYGEN-CONTAINING FUNCTIONAL GROUPS SELECTED FROM ALCOHOL, ETHER, ALDEHYDE, KETONE, ESTER, INORGANIC ESTER, ACETAL, EPOXIDE AND PEROXIDE

Field of the Invention

The present invention relates to motor fuel for diesel, gas-turbine, and turbojet engines, and especially for standard engines, which motor fuel includes fuel compositions of organic compounds containing bound oxygen, and, optionally, also hydrocarbon compounds. Additionally, this invention relates to motor fuel for such engines, and especially diesel engines, in which the fuel composition constitutes a stable, homogeneous liquid at a pressure and an ambient temperature, being normal operational conditions of said engines.

Background to the Invention

The problem of the reduction of pollutants in the exhaust emissions of diesel-driven engines is a challenge to modern society. It is proposed to replace diesel oil as a fuel for vehicles, as represented by, for example, EN 590 and No. 2 diesel oil, and the like, because of environmental reasons and also due to its effects on health. There are international agreements providing for the progressive tightening of the requirements concerning the amount of toxic products resulting from the combustion of motor fuel in the exhaust emissions of vehicles and other machines using diesel engines. In the European Union countries and in the USA the requirements of Step II come into force starting from year 2002. The requirements stipulate significant decreases of carbon monoxide (CO), mixtures of hydrocarbons and nitrogen oxides (HC+NO_x), and particles in the exhaust emissions of diesel engines.

Moreover, modern society is preoccupied with the damage to the global balance of carbon dioxide in the atmosphere, which is linked to the intensive burning of petroleum products, coal and fossil gas. The damage to the carbon dioxide balance in the atmosphere causes global climate warming and has a negative influence on the nature of our planet.

In this connection the development of motor fuel for engines obtained from renewable plant resources is of real significance.

- 5 The growing concern for the protection of the environment and for stricter standards in the content of harmful components in exhaust emissions forces industry to develop urgently various alternative fuels which burn more cleanly.

10 The existing global inventory of vehicles and machinery with standard diesel, gas-turbine and turbojet engines does not currently allow the complete elimination of, as a motor fuel, hydrocarbon mixtures obtained from mineral resources, such as from crude oil, coal and natural gas, an example of such a hydrocarbon mixture being diesel oil.

- 15 On the other hand it is possible to replace a portion of hydrocarbons in motor fuel, such as diesel oil, with other organic compounds which provide cleaner emission exhaust and do not adversely affect engine performance. Gasolines comprising oxygen-containing compounds are presently widely used. It is also known, for instance, that the replacement in motor fuel of 15% of the diesel oil by alcohol
20 provides cleaner exhaust and provides acceptable power without modification of existing diesel engines.

However, the problem of using the most widely available and inexpensive alcohols, methanol and ethanol, as a portion of a motor fuel is that these compounds are
25 immiscible with diesel and gasoil fuels. Potentially, alcohols and other oxygen containing compounds should yield environmentally clean products of combustion. However, the combustion process in engines is an extremely complicated phenomenon, which is affected not only by the composition of the fuel, but also by the physical parameters of the fuel, and, initially by the homogeneity of the liquid.

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The feasibility and properties of mixtures of petroleum diesel fraction with ethanol was reported long ago, such as in Technical Feasibility of Diesohol, ASAE Paper 79-1052, 1979. It was stressed in that article that the main problem of the use of such a fuel is its tendency for phase separation. Furthermore, such phase separation is
35 significantly affected by the presence of water in the system. At 0°C a water content

of only 0.05% causes separation of motor fuel consisting of 99% diesel and 0.95% ethanol.

5 It is widely known that NO_x emission can be reduced by reducing the combustion temperature. One way of achieving reduced combustion temperature is by adding water to the fuel or separately injecting water in the combustion chamber.

10 However, by adding water phase separation will occur in most fuel systems, especially at lower temperatures, i.e., e.g. below 0°C. EP-A-0 014 992 (BASF) and US Patent 4,356,001 (to W. M. Sweeney) addresses the problem of water in the fuel composition by including in the fuel polyethers and/or acetals with or without methanol or ethanol. However, when formulating fuel compositions according to the patent one will find that the improved water tolerances are not sufficient in a wider temperature range. The emissions of CO, hydrocarbons and soot from such
15 fuels are remarkably higher than acceptable.

It is known that alcohol-containing fuels provide relatively low emissions of carbon, carbon oxide and nitrogen oxide (Johnson R.T., Stoffer J.O., Soc. Automot. Eng. (Spec. Publ.) 1983, S.P. 542, 91-104).

20

A significant part of the developments in the field of hybrid diesel fuels is dedicated to the creation of microemulsions. Microemulsions are thermally stable colloid dispersions in which the particle diameter is on the order of 20-30 Å. In 1977 Backer proposed employing surfactants to form microemulsions of alcohols and
25 hydrocarbons (GB Patent No. 2,002,400, granted July 12, 1977). Later, for the same purposes other emulgators were proposed (GB Patent No. 2,115,002, granted February 1, 1982; U.S. Patent No. 4,509,950, issued March 24, 1985; U.S. Patent No. 4,451,265, issued April 21, 1984; and European Patent No. 475,620, published March 18, 1992).

30

It is possible to achieve a homogeneous composition of diesel fuel incorporating different alcohols and their mixtures. In the French Patent No. 2453210 published October 31, 1980, in order to achieve a homogeneous liquid incorporating hydrocarbons and methanol, it is proposed to add also primary aliphatic saturated
35 alcohols of linear and branched structures having from 8 to 15 carbon atoms or mixtures of such alcohols. The avoidance of the separation of the hybrid fuel

incorporating the alcohol mixture allows the development covered by the European Patent No. 319060, published June 7, 1989.

5 The study of the performance characteristics of the hybrid fuels confirms the possibility of their use for the operation of diesel engines (Mathur H.B., Babu M.K. Indian Inst. Techn. Journ. Therm. Eng., 1988, 2(3), p. 63-72. Haschimoto, K., et al., Journ. Jap. Petrol. Inst., 1996, v. 39, N2, p. 166-169).

10 In W095/02654 (published January 26, 1995), in order to achieve a homogeneous fuel blend the patentees propose using a formulation containing up to 20% of the total volume of ethanol and/or n-propanol, up to 15% of the total volume of fatty acid and/or organic ester, and the remainder a hydrocarbon liquid. The patent provides examples of compositions in which oleic acid as well as different organic esters are used in addition to diesel, ethanol and propanol.

15 In accordance with W095/02654 all the Examples are said to illustrate fuel compositions having a single phase. This is said to demonstrate the effectiveness of using certain amounts of fatty acids and/or organic esters, as well as their mixtures, in order to obtain homogeneous liquids incorporating diesel and low alkyl
20 alcohols in addition to those mentioned above. However, the patent does not any state temperature limits of stability of the obtained fuel formulations, and is silent as to how the presence of any water affects their stability. On the other hand, it is known that stability of mixtures of lower alcohols and diesel is one of the main operational properties of such fuels. It is stated in W095/02654 that tests of
25 several compositions in various standard diesel engines did not show a decrease of power and efficiency of the fuel. However, nothing is said regarding the content of the exhaust emissions of different engines using the fuel formulations proposed. The only comment in that regard is that the use of the ethanol blend over several months in the engine of a Yale Forklift (model GDP 050 RUAS) Mazda XA was likely
30 to be more acceptable with regard to the condition of the air inside the warehouse where the forklift was operated.

Summary of the Invention

35 The drawbacks mentioned of the fuel compositions of the prior art is eliminated by providing a fuel composition of the present invention including oxygen-containing

compounds exhibiting at least four oxygen-containing functional groups, selected from alcohol, aldehyde, ketone, ether, ester, inorganic ester, acetal, epoxide (also referred to as oxirane), and peroxide groups, wherein said at least four groups can be contributed to by any combination of two or more different oxygen-containing
5 compounds, each of which contains at least one of said groups and, optionally, hydrocarbon compounds.

The composition thus obtained will form a homogeneous liquid fuel tolerant to the presence of water over a wide range of temperatures. Employing the inventive
10 motor fuel as a replacement of a ordinary motor fuel for operating a standard engine demonstrates considerable reduction of pollutants in the exhaust emissions, including emissions of NO_x, and particles. Moreover, the use of components obtained from renewable raw material reduces emission into the atmosphere of the excess carbon dioxide.

15 According to the invention a fuel is provided that can be used in existing, standard engines, including diesel engines, advantageously without any changes in fuel injection synchronisation, valve timing and valve opening time. It is thus possible to switch between conventional fuels and fuels according to the present invention
20 without any engine modification. Such a property is of great practical value.

Contrary to a large number of fuel compositions of the prior art which have been used to replace diesel fuel in part or totally, especially such compositions containing carboxylic acids, the fuel of the present invention is essentially non-
25 corrosive.

A further advantage of the present invention is that, due to the flexibility of the composition of the fuel, it is possible to adapt the same so as to take advantage of the current prices at a given time of the specific constituents, or even replace any
30 constituents in order to produce a cheaper fuel, if desired. It is, for example, possible to let the price and availability of any hydrocarbons used govern the contents of the fuel compositions.

Most advantageously, the method of preparing the fuel of the present invention
35 does not require any vigorous mixing of the constituents, such as in the prior art.

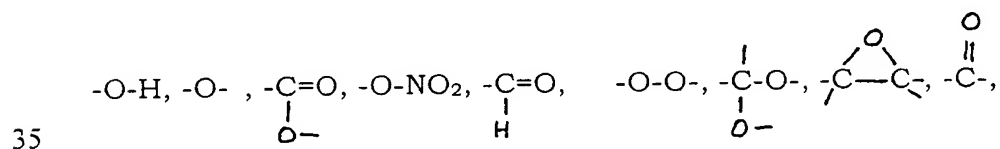
Thus, no intensive stirring of the mixture is required in order to obtain a homogeneous fuel composition of the present invention.

Thus, according to the present invention a homogeneous fuel composition providing efficient operation of diesel, gas-turbine and turbojet engines, including standard engines and reduced emission of pollutants in the exhaust emission is obtained by employing oxygen-containing compounds comprising at least four oxygen-containing functional groups, wherein said groups can be contributed to by any combination of two or more different oxygen-containing compounds, each of which contains at least one of said groups, preferably by employing at least four types of organic compounds differing in functional groups containing bound oxygen.

This invention is based, inter alia, on employing as a motor fuel the above-mentioned combination of organic compounds containing bound oxygen, with or without hydrocarbons, forming a homogeneous liquid at ambient temperature and ordinary pressure in the environment wherein the engine is operated. When used as a motor fuel the above-mentioned combination of the organic compounds containing bound oxygen, and optionally, hydrocarbons, provides the required operational characteristics of said engines, and a surprisingly reduced amount of pollutants in the exhaust emissions.

It has surprisingly been found that, if brought to temperatures below the cloud point or to temperatures above the starting boiling point, so that a phase separation will occur, the inventive fuel compositions subsequently, when allowed to return to temperatures within the temperature range between the cloud point and the initial boiling point of the specific fuel composition, will re-homogenise.

In one aspect of the invention a motor fuel comprises at least four different oxygen-
30 containing functional groups contained in any number of organic compounds,
wherein the oxygen can be bound in any of the following functional groups:



and, optionally, hydrocarbon compounds.

In another embodiment of the invention a motor fuel composition for diesel, turbojet and jet engines, including standard engines, has reduced emission of pollutants and comprises an oxygen-containing organic component containing at least one compound of each of at least four of an alcohol, an aldehyde, a ketone, an ether, an ester, an inorganic ester, an acetal, an epoxide, and peroxide, and, optionally a hydrocarbon component.

10 DETAILED DESCRIPTION OF THE INVENTION

In general, the oxygen-containing organic compound component is present in amounts from about 5% to 100% based on the total volume of the motor fuel composition and, when present, the hydrocarbon component is employed in amounts from 0 to about 95%, based on the total volume of the motor fuel composition.

In general, the motor fuel composition is preferably stable at atmospheric pressure over a temperature range from a cloud temperature of as low as about -35°C to an initial boiling temperature of about 180°C.

The preferred homogeneous motor fuel composition has a cloud point not higher than about -50°C and an initial boiling point not lower than about 50°C.

25 The motor fuel composition preferably exhibits at least one, more preferably a portion, and, most preferably, all of the following properties:

- (i) density at 20°C of not less than 0.775 g/cm³;
- (ii) the cloud temperature is not higher than 0°C at atmospheric pressure;
- (iii) stable at atmospheric pressure from cloud temperature of 0°C to initial boiling point of 50°C;
- (iv) amounts of liquid evaporated by boiling at atmospheric pressure;
 - not more than 25% of the total volume of the motor fuel composition distills no higher than 100°C;
 - 35 - not more than 35% of the total volume of the motor fuel composition distills at temperatures no higher than 150°C;

- not more than 50% of the total volume of the motor fuel composition distills at temperatures no higher than 200°C;
- not less than 98% of the total volume of the motor fuel composition distills at temperatures no higher than 400 °C, suitably no higher than 370°C; and preferably no higher than 280°C;

- (v) heat of combustion on oxidation by oxygen of not less than 39 MJ/kg;
- (vi) self-ignition temperature from 150°C to 300°C.
- (vii) ability to accommodate at least 1% water by volume.

10 The motor fuel composition is preferably produced by successively introducing into a fuel reservoir at the same temperature, the components of the motor fuel composition beginning with the component having the least density at that temperature and terminating with the component having the highest density at that temperature.

15

A heavier hydrocarbon fraction is typically employed in combination with the oxygen-containing components. The hydrocarbon fraction employed is generally any hydrocarbon mixture, such as a petroleum fraction, meeting ASTM specifications for diesel fuel. Depending on grade, actual hydrocarbon fractions will vary. No. 2 diesel fuel, having its European counterpart in EN 590 diesel fuel, is most commonly used in commercial and agricultural vehicles and increasingly, in private vehicles. Of course other hydrocarbon fractions lighter than the diesel fraction, including kerosene, as well as fractions heavier than the diesel fraction, including gas oil and fuel oil, could be used in the present motor fuel, to replace the diesel fraction.

25

The hydrocarbon component of the instant motor fuel composition, when employed, is preferably a diesel fraction. The diesel fraction is preferably a mixture of a diesel oil and the hydrocarbon fraction lighter than the diesel oil. It is also possible to employ a hydrocarbon liquid obtained from a renewable raw material as a component of the motor fuel for diesel engines. It is preferred to employ the hydrocarbon liquids obtained from turpentine or rosin, as well as hydrocarbon liquids produced by processing of oxygen containing compounds.

30

35 The hydrocarbon component of the motor fuel for diesel engines, when employed, can be produced from synthesis-gas, or natural gas and coal.

Preferably, at least one of methanol or ethanol, and, optionally, products derived from said methanol and/or ethanol, are present in the oxygen-containing compound component. The components of the motor fuel may contain
5 contaminants, which reduce the time and expense in processing the components for use in the fuel.

In a preferred embodiment of the invention amounts in the order of 1% water based on the total volume of the motor fuel composition may be present without
10 significantly undesirably affecting the properties and homogeneity of the motor fuel compositions. Accordingly, components and hydrocarbon fractions commercially available containing water need not necessarily be treated to remove water prior to incorporation in the motor fuel.

15 It is also a preferred feature of the invention that the oxygen containing organic compound component is employed from a renewable plant resource.

According to a preferred embodiment of the invention, for a fuel composition providing a shorter period of delay in the ignition of the motor fuel, the organic
20 compounds containing bound oxygen preferably have a linear or sparsely branched molecular structure.

According to another preferred embodiment of the invention, for a fuel composition containing organic compounds containing bound oxygen with a branched
25 molecular structure in order that the efficiency of operation is not reduced, the temperature of self-ignition of the motor fuel composition is between about 150°C and 300°C.

In accordance with a further preferred embodiment of the invention a fuel
30 composition is provided for efficient operation of engines and exhibiting reduction of pollutants in the exhaust emissions, without the addition of hydrocarbons. For this purpose, only the organic compounds containing bound oxygen are employed.

The instant motor fuel composition can be utilised under conditions of either
35 reduced and/or increased ambient temperature with satisfactory efficiency in operation.

In accordance with a further preferred embodiment of the invention an oxygen containing components provide the required lubrication properties of the motor fuel, which is of particular importance for proper operation of diesel engine.

5

According to another preferred embodiment of the invention an oxygen containing components provide reduction of deposit in the combustion chamber of the engine.

10 The oxygen-containing component of the motor fuel of the invention preferably includes (i) alcohols, (ii) ethers, (iii) organic esters and (iv) at least one of aldehyde, ketone, inorganic ester, acetal, epoxide, and peroxide.

In a most preferred embodiment, the fuel composition of the invention comprises at least one compound of each of the different classes included in (i) to (iv) above.

15

Mixtures of alcohols, such as (i) ethanol and butanol, (ii) ethanol, propanal and hexanol, (iii) methanol and ethanol, (iv) ethanol, butanol and hexanol and (v) ethanol, propanol, butanol, pentanol, ethyl-hexanol, and trimethylnonanol and the like may preferably be employed as the alcohol component. Further, mixtures
20 of ethers, and mixtures of organic esters may also be utilised for the ethers or organic ester component, respectively, with satisfactory results. Likewise, mixtures of any of each of acetals, epoxides, peroxides, aldehydes, ketones and inorganic esters may be employed for such components.

25 When three or fewer different classes of oxygen-containing components are employed to form the instant motor fuel composition for diesel engines it has been found that it is difficult to readily form a homogeneous, single phase fuel. For example, when diesel oil is combined with ethanol, oleic acid and isopropyl oleate as in Composition 10 of W095/02654 by adding to diesel oil ethanol, oleic acid and
30 isopropyl oleate, and the mixture is permitted to stand for an hour, a multi-phase composition is generally observed. Only with substantial shaking does the phase separation disappear. To the contrary, in the present invention where four different classes of oxygen-containing compounds are employed and the components are mixed in order of increasing density and the mixture allowed to stand for at least
35 about an hour, a single phase mixture is obtained without the need for external mixing.

The oxygen-containing compound can include an alcohol. In general, aliphatic alcohols, preferably alkanols, and mixtures thereof are employed. More preferably, alkanols of the general formula: R-OH, in which R is alkyl with 1 to 10 carbon atoms, most preferably 2 to 8 carbon atoms, such as ethanol, n-, iso- or sec-butyl, or amyl alcohol, 2-ethylhexanol, or 2,6,8-trimethyl-4-nonanol are employed.

The fuel additive can include an aldehyde of the general formula $\text{R}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{H}$, where R is a C₁-C₈ hydrocarbon.

Preferred aldehydes include formaldehyde, ethylaldehyde, butylaldehyde, isobutylaldehyde and ethylhexylaldehyde.

The fuel additive can include a ketone of the general formula $\text{R}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{R}_1$, wherein R and R₁ each are a C₁ - C₈ hydrocarbon residue, the same or different or, together, form a cyclic ring, the total number of carbon atoms of R and R₁ being 3 to 12. The preferred ketones of the invention include diisobutyl ketone, ethylamyl ketone, carvon, and menthone.

The ether fuel additive preferably includes a monoether, a diether and/or a cycloether. A preferred ether has the general formula R-O-R', wherein R and R' are the same or different and are each a C₂-C₁₀ hydrocarbon group or, together, form a cyclic ring. In general, lower (C₄-C₈,) dialkyl ethers are preferred.

The total number of carbon atoms in the ether is preferably from 8 to 16.

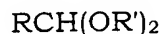
Typical monoethers include dibutyl ether, tert-butyl isobutyl ether, ethylbutyl ether, diisoamyl ether, dihexyl ether and diisooctyl ether. Typical diethers include dimethoxy propane and diethoxy propane. Typical cycloethers include cyclic mono, di, and heterocyclic ethers as dioxane, methyl tetrahydrofuran, methyl tetrahydropyran, and tetrahydrofurfuryl alcohol.

The ester additive may be an ester of an organic acid of the general formula

$\text{R}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{O}-\text{R}'$, where R and R' are the same or different. R and R' are preferably hydrocarbon groups. Preferably C₁-C₈ alkyl esters of C₁-C₂₂ saturated or

unsaturated fatty acids. Typical esters include ethyl formate, methyl acetate, ethyl acetate, propyl acetate, isobutyl acetate, butyl acetate, isoamyl acetate, octyl acetate, isoamyl propionate, methyl butyrate, ethyl butyrate, butylbutyrate, ethyl oleate, ethyl caprylate, rape seed oil methyl ester, isobornylmethacrylate and the like.

The acetal fuel additive can have the general formula:

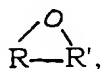


wherein R is hydrogen or hydrocarbyl, preferably lower alkyl, i.e. (C₁-C₃) and R' is C₁-C₄ alkyl, such as methyl, ethyl or butyl. Typical acetals include formaldehyde dimethyl acetal, formaldehyde diethyl acetal, acetaldehyde diethyl acetal and acetaldehyde dibutyl acetal.

The oxygen-containing compound of the invention can be an inorganic acid ester which is an organic ester of an inorganic acid. A typical inorganic acid is nitric acid and the organic moiety can be hydrocarbyl, preferably alkyl or alicyclic. Typical examples of the inorganic acid ester include cyclohexyl nitrate, isopropyl nitrate, n-amyl nitrate, 2-ethylhexyl nitrate, and iso-amyl nitrate.

The oxygen containing compound can be an organic peroxide. Typical organic peroxides are of the formula R-O-O-R' where R and R' are each the same or different and can be, for example, alkyl or oxygen-substituted alkyl, such as alkanoic. Examples of organic peroxides include tert-butyl hydroperoxide, tert-butyl peroxyacetate and di-tert butyl peroxide.

The oxygen containing compound can be an organic epoxide. Typical organic epoxides have the general formula



where R and R' are C₁ - C₁₂, and are the same or different and are hydrocarbyl, preferably alkyl and alkanoic. Typical epoxides include 1,2-epoxy-4-epoxy ethylcyclohexan, epoxidised methyl ester of tall oil, ethylhexylglycidyl ether.

The oxygen-containing fuel additives are employed in effective amounts to provide a homogenous motor fuel and an efficient fuel having reduced emissions. Usually, at least about 5% by volume of oxygen containing additive is employed. Further, a

completely hydrocarbon-free fuel which is 100% oxygen-containing component can be employed.

5 The minimum amount of any of the at least four functional groups, calculated as the total volume of the compound(s) exhibiting the particular group, should not be lower than 0.1%, suitably not lower than 0.5%, and preferably not lower than 1% of the total volume of the fuel composition

10 In general, the alcohol is preferably employed in amounts from about 0.1 to 35% by volume; the aldehyde in amounts from about 0 to 10% by volume, the ether in amounts from about 0.1 to 65% by volume, the organic ester in amounts from about 0.1 to 20% by volume, the acetal in amounts from 0 to 10% by volume, the inorganic ester in amounts from about 0 to 2% by volume, the peroxide in amounts from about 0 to 2% by volume, and the epoxide in amounts from about from about
15 0 to 10%, although greater and lesser amounts can be employed depending on the particular circumstances for a given motor fuel composition useful in a diesel engine.

20 The alcohol, or any other component of the fuel composition, may be present therein as a by-product contained in any of the other components.

The organic compounds containing bound oxygen can be derived from fossil-based sources or from renewable sources as biomass.

25 As non-limiting examples demonstrating the effectiveness of this invention the illustrative motor fuel compositions which are described hereafter are particularly suitable for the operation diesel, gas-turbine and turbojet engines, including standard types of engines, without any modification thereof.

30 EXAMPLE 1

Motor Fuel Composition 1 prepared below demonstrates that even when a very small quantity of organic compounds containing bound oxygen are employed, they provide a noticeable reduction of pollutants in the exhaust emission of a standart
35 diesel engine.

The content by volume of components in the Motor Fuel Composition 1 is as follows: formaldehyde diethyl acetal - 1%; 1-butanol - 1%; di-n-amyl ether - 1.75%; octyl acetate - 1%; isopropyl nitrate - 0.25%; and hydrocarbon liquid (diesel fuel according to standard EN 590) - 95%.

5

The fuel components were added to a common tank starting with the component with the lowest density and ending with the component having the greatest density. The resulting motor fuel composition had the following characteristics:

10	Density at 20°C	0.811 g/cm ³
	Temperature limits of evaporation by boiling of the liquid at atmospheric pressure	
	up to 100°C	1%
	up to 150°C	2.25%
15	up to 200°C	14.5%
	up to 370°C	98.0 %
	Heat of combustion	42.8 MJ/kg
	Thermal stability	Motor Fuel Composition 1 was a homogeneous liquid, stable at
20		atmospheric pressure over a range of temperatures from -18°C (cloud temperature) to 88°C (initial boiling temperature).
25	An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: D1- W03-92 when executing Test Type, - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441 /EEC) on Motor Fuel Composition 1 showed a reduction in particles (g/km) of 5% in comparison to the results obtained for 100% diesel fuel (EN590:1993).	
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The use of Motor Fuel Composition 1 in the operation of the standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, showed for measurements over the range of 1000 -
2600 rpm, a decrease in the values of power and torque of less than 1% in

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comparison with the values obtained for the same engine operating on 100% diesel fuel (EN590:1993).

Similar results were obtained when employing the Motor Fuel Composition 1 for operation of the standard ship gas-turbine engine.

EXAMPLE 2

Motor Fuel Composition 2 produced a significant decrease of pollutants in the exhaust emissions of a standard diesel engine operating with an inexpensive fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid.

The content by volume of the components in Motor Fuel Composition 2 is as follows: ethanol - 3%; 1-butanol -2.5%; dimethoxypropane - 3%; tetrahydrofurane - 1.5%; tert-butyl hydroperoxide - 0.5%; and hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 89.5%.

The fuel composition had the following characteristics:

Density at 20°C	0.817 g/cm ³
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Temperature limits of evaporation by boiling of the liquid at atmospheric pressure:	
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up to 100°C	8%
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up to 150°C	10.5%
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up to 200°C	19.5%
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up to 285°C	95.5%
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Heat of combustion	41.9 MJ/kg
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Thermal stability	Motor Fuel Composition 2 is a homogeneous liquid, stable at atmospheric pressure over a range of temperatures from -30°C (cloud temperature) to 70°C (initial boiling temperature).
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An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family

2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 2, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/km) of 12%; HC+NO_x (g/km) of 5.75% and particles (g/km) of 11.5%.

An analysis of the amount of the pollutants in the exhaust emissions from a standard diesel truck engine, Engine Type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation for fuel composition 2, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of: CO (g/kW) of 6%; HC+NO_x (g/kW) of 0%, and particles (g/kW) of 4%.

The power (PkW) of the engine when operating on Motor Fuel Composition 2 decreased only by 2.8%, and the fuel consumption (l/kW) slightly increased by 2% in comparison to the results obtained for the same engine operating on 100% Mk1 diesel fuel (SS 15 54 35).

EXAMPLE 3

20

Motor Fuel Composition 3 produced a significant decrease of pollutants in the exhaust emissions of a standard diesel engine operating with an inexpensive fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid, which liquid is a mixture of hydrocarbons obtained from a synthesis-gas "synthin".

25

The content by volume of the components in Motor Fuel Composition 3 is as follows: ethanol - 3%; 1-butanol - 2.5%; dimethoxypropane - 3%; ethyl acetate - 1.5%; tert-butyl hydroperoxide - 0.5%; and hydrocarbon liquid (hydrocarbon mixture obtained from synthesis-gas with catalyst under atmospheric pressure and temperatures of 170 - 200 °C) - 89.5%.

30

The fuel composition had the following characteristics:

35

Density at 20°C 0.817 g/cm³
Temperature limits of evaporation by boiling of

the liquid at atmospheric pressure:

up to 100°C	7%
up to 150°C	10.5%
up to 200°C	19.5%
5 up to 285°C	95.5%

Heat of combustion 41.7 MJ/kg

Thermal stability Motor Fuel Composition 3 is a homogeneous liquid, stable at atmospheric pressure over a range of temperatures from -30°C (cloud temperature) to 70°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 3, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/km) of 18%; HC+NO_x (g/km) of 5.05% and particles (g/km) of 21.5%.

An analysis of the amount of the pollutants in the exhaust emissions from a standard diesel truck engine, Engine Type: VOLVO D7C 290 EUR02 No. 1 162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation for fuel composition 3, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of: CO (g/kW) of 11%; HC+NO_x (g/kW) of 4.8%, and particles (g/kW) of 17%.

The power (PkW) of the engine when operating on Motor Fuel Composition 3 decreased only by 1.2%, and the fuel consumption (l/kW) slightly increased by 0.5% in comparison to the results obtained for the same engine operating on 100% Mk1 diesel fuel (SS 15 54 35).

EXAMPLE 4

Motor Fuel Composition 4 demonstrated the effects of operating a standard diesel engine with a fuel composition of organic compounds containing bound oxygen and

a hydrocarbon liquid containing lighter fractions of petroleum products in addition to diesel fuel.

The content by volume of the components in the fuel composition were as follows:

- 5 ethanol - 8%; 1-butanol - 2%; diethyl acetaldehyde - 0.5%; ethyl acetate - 4%; ethyl butyrate - 3%; acetaldehyde diethyl acetal - 0.5%; di-n-amyl ether - 8%; ethyl oleate - 8%; tert-butyl peroxyacetate - 1%; hydrocarbon liquid - 65%; containing 15% kerosene and 50% Mk1 diesel fuel (SS 15 54 35).

- 10 The fuel composition had the following characteristics:

Density at 20°C 0.775 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

- | | | |
|----|-------------|-----|
| | up to 100°C | 12% |
| 15 | up to 150°C | 19% |
| | up to 200°C | 43% |
| | up to 285°C | 96% |

Heat of combustion 40.2 MJ/kg

- 20 Thermal stability Motor Fuel Composition 4 is a homogeneous liquid stable at atmospheric pressure over a range of temperatures from -37°C (cloud temperature) to 70°C (initial boiling temperature).

25

- An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2Dl-W-DE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 4, showed in comparison to 100% Mk1 diesel fuel (SS 30 15 54 35), a reduction in the amounts of CO (g/km) of 27.7%, HC+NO_x (g/km) of 12.6% and particles (g/km) of 17%.

- 35 When Motor Fuel Composition 4 was employed the operation of the standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, the resulting measurements over the

range from 1000 - 2600 rpm showed a decrease in the values of power and torque of less than 3.5% in comparison to the values obtained for the same engine operating on the 100% Mk1 diesel fuel (SS 15 54 35).

5 EXAMPLE 5

Motor Fuel Composition 5 demonstrated the effects of operating a standard engine with a fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid containing a kerosene fraction of petroleum products in
10 addition to synthetic motor fuel.

The content by volume of the components in the fuel composition were as follows:
1-butanol - 1%; 2-ethyl hexanol - 3%; 2-ethylhexyl acetate - 1%; isoamyl alcohol -
1%; di-isoamyl ether - 2%; tetrahydrofurfuryl alcohol - 1.5%; iso-amyl nitrate -
15 0.5%; hydrocarbon liquid - 90%, containing 40% of kerosene and 50% synthin (a hydrocarbon mixture obtained from synthesis-gas with catalyst under atmospheric pressure and temperatures of 150 - 280 °C).

The fuel composition had the following characteristics:

20 Density at 20°C 0.805 g/cm³

Temperature limits of evaporation of the
liquid by boiling at atmospheric pressure:

	up to 100°C	0%
	up to 150°C	2%
25	up to 200°C	43.5%
	up to 280°C	99%

Heat of combustion 43.3 MJ/kg

Thermal stability Motor Fuel Composition 5 is a
homogeneous liquid stable at
30 atmospheric pressure over a range of
temperatures from -60°C (cloud
temperature) to 70°C (initial boiling
temperature).

35 An analysis of the amount of pollutants in the exhaust emissions from the
standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine

Family 2D1-W-DE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 5, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/km) of 12.6 %, HC+NO_x (g/km) of 7.4% and particles (g/km) of 26%.

When Motor Fuel Composition 5 was employed the operation of the standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, the resulting measurements over the range from 1000 - 2600 rpm showed a decrease in the values of power and torque of less than 1% in comparison to the values obtained for the same engine operating on the 100% Mk1 diesel fuel (SS 15 54 35).

Similar results for power and exhaust emission changes were obtained when employing the Motor Fuel Composition 5 for operation of the standard aeroplane jet engine.

EXAMPLE 6

Motor Fuel Composition 6 demonstrated the possibility of using for operating a standard diesel engine a fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid in which the concentration of the hydrocarbon in the composition was less than 40% by volume.

The content by volume of the components in Motor Fuel Composition 6 is: ethanol - 4.5%; propanol - 5.5%; hexanol - 15%; dibutyl ether - 8.5%; ethyl caprylate - 10%; dihexyl ether - 16%; di-tert-butyl peroxide - 1.5%; and hydrocarbon liquid (diesel fuel EN 590: 1993) - 39%.

The fuel composition had the following characteristics:

Density at 20°C 0.819 g/cm³

Temperature limits of evaporation by boiling
of the liquid at atmospheric pressure:

up to 100°C	10%
up to 150°C	20 %
up to 200°C	39%

up to 370° C

98%

Heat of combustion

40.4 MJ/kg

Thermal stability

Motor Fuel Composition 6 was a homogeneous liquid stable at atmospheric pressure over a range of temperatures from -35°C (cloud temperature) to 78°C (initial boiling temperature).

5

- 10 An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the Audi A6 TDI 1.9 automobile, model 1998 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), showed for Motor Fuel Composition 6 in comparison to 100% Mk1 diesel fuel (EN 590: 1993) a reduction in the amounts of CO (g/km) of 0 %, HC+NO_x g/km) of 14 % and particles (g/km) of 46 %.

15

Example 7

- 20 Motor Fuel Composition 7 demonstrated the possibility of using for operating a standard diesel engine a fuel composition of organic compounds containing bound oxygen and a hydrocarbon liquid in which composition the concentration of the hydrocarbon was less than 40% by volume, and wherein the hydrocarbon mixture was obtained from a liquid fraction obtained in mineral coal coking.

25

The content by volume of the components in Motor Fuel Composition 7 is: ethanol - 4.5%; propanol - 5.5%; hexanol - 15%; dibutyl ether - 8.5%; ethyl caprylate - 10%; dihexyl ether - 16%; 2-ethylhexylglycidyl ether - 1.5%; and hydrocarbon liquid - 39%, obtained from mineral coal processing, and including 9% of decalin.

30

The fuel composition had the following characteristics:

Density at 20°C

0.820 g/cm³

Temperature limits of evaporation by boiling of the liquid at atmospheric pressure:

up to 100°C

10%

35

up to 150°C

18.5 %

up to 200°C

39%

up to 400°C
Heat of combustion
Thermal stability

98%

40.4 MJ/kg

Motor Fuel Composition 7 was a homogeneous liquid stable at atmospheric pressure over a range of temperatures from -35°C (cloud temperature) to 78°C (initial boiling temperature).

5

10 An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the Audi A6 TDI 1.9 automobile, model 1998 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), showed for Motor Fuel Composition 7 in comparison to 100% diesel fuel (EN 590: 1993) a reduction in the amounts of CO (g/km) of 8 %, HC+NO_x
15 g/km) of 12 % and particles (g/km) of 45 %.

Similar results were obtained when employing the Motor Fuel Composition 7 for operation of the standard ship gas-turbine engine.

20

EXAMPLE 8

Motor Fuel Composition 8 demonstrated the possibility of using for operating a diesel engine a fuel composition made from a hydrocarbon liquid and from organic compounds containing bound oxygen which compounds can be obtained by
25 processing methanol and ethanol.

The content by volume of the components in Motor Fuel Composition 8 is:
methanol - 1.5%; ethanol - 3%; formaldehyde dimethyl acetal - 2%; formaldehyde diethyl acetal - 3%; acetaldehyde diethyl acetal - 3%; methyl acetate - 1%; ethyl
30 formate - 1%; rape seed oil methyl ester - 5%; ethyl oleate - 5%; tert-butyl peroxyacetate - 0.5%; hydrocarbon liquid (kerosene) - 75%.

The fuel compositions had the following characteristics:

Density at 20°C

0.791 g/ cm³

35

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

	up to 100°C	11.5%
	up to 150°C	15%
	up to 200°C	25%
	up to 280°C	97.5%
5	Heat of combustion	40.4 MJ/kg
	Thermal stability	Fuel composition 8 was a
		homogeneous liquid stable at
		atmospheric pressure over a range of
10		temperature from -48°C (cloud
		temperature) to 52.5°C (initial boiling
		temperature).

An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, engine family 2Dl-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), showed for Motor Fuel Composition 8 - in comparison to 100% Mk1 diesel fuel (SS 15 54 35) - a reduction in the amounts of CO (g/km) of 18%, HC+NO_x (g/km) of 8.6% and particles (g/km) of 31.6%.

The use of Motor Fuel Composition 8 for the operation of the standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, showed for measurements over the range from 1000 - 2600 rpm, a decrease in the values of power and torque of less than 4% in comparison with the results obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

Example 9

Motor Fuel Composition 9 demonstrated the possibility of using for operating a diesel engine a fuel composition made from organic compounds containing bound oxygen, which compounds can be obtained by processing methanol and ethanol and a hydrocarbon liquid obtained in processing of turpentine and rosin.

The content by volume of the components in Motor Fuel Composition 9 is: methanol - 1.5%; ethanol - 3%; formaldehyde dimethyl acetal - 2%; formaldehyde

diethyl acetal - 3%; acetaldehyde diethyl acetal - 3%; methyl acetate - 1%; ethyl formate - 1%; tall oil methyl ester - 10%, including methyl abietate - 3.5%; tert-butyl peroxyacetate - 0.5%; hydrocarbon liquid - 75% (a mixture of hydrocarbons obtained in processing of turpentine and rosin, comprising menthane - 45%,
 5 abiethane - 10%, and the remaining part of other terpene hydrocarbons).

The fuel compositions had the following characteristics:

Density at 20°C 0.821 g/ cm³

Temperature limits of evaporation of the

10 liquid by boiling at atmospheric pressure:

up to 100°C 11.5%

up to 150°C 15%

up to 200°C 25%

up to 400°C 98.75%

15 Heat of combustion 40.4 MJ/kg

Thermal stability

Fuel composition 9 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -33°C (cloud
 20 temperature) to 52.5°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, engine
 25 family 2DI-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), showed for Motor Fuel Composition 9 - in comparison to 100% Mk1 diesel fuel (SS 15 54 35) - a reduction in the amounts of CO (g/km) of 16%, HC+NO_x (g/km) of 10.5% and particles (g/km) of 40.5%.

30

The use of Motor Fuel Composition 9 for the operation of the standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, showed for measurements over the range from 1000 - 2600 rpm, a decrease in the values of power and torque of less than 3% in
 35 comparison with the results obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

Similar results were obtained when employing the Motor Fuel Composition 9 for operation of the standard ship gas-turbine engine.

5

EXAMPLE 10

10

Motor Fuel Composition 10 demonstrated the possibility of using for operating a diesel engine a fuel composition of a hydrocarbon liquid and of organic compounds containing bound oxygen which compounds are not thoroughly purified technical products.

15

The content by volume of the components in the Motor Fuel Composition 10 is: ethanol - 4.5%; propanol - 12.5%; 1-butanol - 1%; isobutanol - 0.5%; 1-pentanol - 1.5%; 2-ethylhexanol - 9.5%; ethyl acetate - 1%; propyl acetate - 6%; isobutyl acetate - 0.1%; amyl acetate - 0.4%; butyl aldehyde - 0.8%; isobutyl aldehyde - 0.2%; dibutyl ether - 6.5%; di-octyl ether - 5%; n-amyl nitrate - 0.5%; and hydrocarbon liquid (diesel fuel SS 15 54 35 Mkl) - 50%.

20

The fuel composition had the following characteristics:

Density at 20°C 0.815 g/cm³

Temperature limits of evaporation of the liquid
by boiling at atmospheric pressure:

25

up to 100°C	25%
up to 150°C	35%
up to 200°C	50%
up to 285°C	97.5%

Heat of combustion

39.0 MJ/kg

Self-ignition temperature

300°C

30

Thermal stability:

Motor Fuel Composition 10 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -35°C (cloud temperature) to 64°C (initial boiling temperature).

35

An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the VW GOLF CL DIESEL automobile, Engine Family: D1-W03-92 when executing Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) showed for Motor Fuel Composition 10 in
5 comparison to the results obtained for 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/km) of 16.9%, HC+NO_x (g/km) of 5.9% and particles (g/km) of 23.7%.

The use of Motor Fuel Composition 10 for the operation of a standard diesel truck
10 engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings: kW/Nm/rpm = 140/520/1900, showed for measurements over the range 1000 - 2600 rpm, a decrease in the values of power and torque of less than 5% in comparison to the corresponding values obtained for the same engine operating with 100% Mk1 diesel fuel (SS 15 54 35).

15

Example 11

Motor Fuel Composition 11 demonstrated the possibility of using for operating a standard diesel engine a fuel composition of organic compounds containing bound
20 oxygen, which compounds are not thoroughly purified technical products and of a hydrocarbon component comprising kerosene, synthin, hydrogenated turpentine and a hydrogenated liquid fraction obtained in mineral coal coking.

The content by volume of the components in the Motor Fuel Composition 11 is:
25 ethanol - 4.5%; propanol - 12.5%; 1-butanol - 1%; isobutanol - 0.5%; 1-pentanol - 1.5%; 2-ethylhexanol - 9.5%; ethyl acetate - 1%; propyl acetate - 6%; isobutyl acetate - 0.1%; amyl acetate - 0.4%; butyl aldehyde - 0.8%; isobutyl aldehyde - 0.2%; dibutyl ether - 6.5%; di-octyl ether - 5%; n-amyl nitrate - 0.5%; and hydrocarbon liquid (comprising a terpene fraction - 10%, including menthane - 8%;
30 kerosene - 10% and synthin - 20%, including linear saturated hydrocarbons - 18%, and a hydrogenated liquid fraction obtained in mineral coal coking - 10%, including decalin - 2%) - 50%.

The fuel composition had the following characteristics:

35

Density at 20°C

0.815 g/cm³

Temperature limits of evaporation of the liquid
by boiling at atmospheric pressure:

	up to 100°C	25%
	up to 150°C	35%
5	up to 200°C	50%
	up to 400°C	98.5%

Heat of combustion 39.0 MJ/kg

Self-ignition temperature 300°C

Thermal stability: Motor Fuel Composition 11 was a

10 homogeneous liquid stable at
atmospheric pressure over a range of
temperature from -35°C (cloud
temperature) to 64°C (initial boiling
temperature).

15

An analysis of the amount of pollutants in the exhaust emissions from the
standard diesel engine of the VW GOLF CL DIESEL automobile, Engine Family: D1-
W03-92 when executing Test Type - Modified European Driving Cycle (NEDC UDC
+ EUDC) ECE OICA (91/441/EEC) showed for Motor Fuel Composition 11 in
20 comparison to the results obtained for 100% Mk1 diesel fuel (SS 15 54 35), a
reduction in the amounts of CO (g/km) of 16.9%, HC+NO_x (g/km) of 5.9% and
particles (g/km) of 23.7%.

The use of Motor Fuel Composition 11 for the operation of a standard diesel truck
25 engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings:
kW/Nm/rpm = 140/520/1900, showed for measurements over the range 1000 -
2600 rpm, a decrease in the values of power and torque of less than 5% in
comparison to the corresponding values obtained for the same engine operating
with 100% Mk1 diesel fuel (SS 15 54 35).

30

EXAMPLE 12

Motor Fuel Composition 12 demonstrated the possibility of using for operating a
standard diesel engine a fuel composition of a hydrocarbon liquid and organic
35 compounds containing bound oxygen which fuel is useful at elevated temperatures.

The content by volume of components in Motor Fuel Composition 12 is: 1-octanol - 2%; ethyl oleate - 4%; ethyl caprylate - 2.5%; di-n-amyl ether 4%; di-octyl ether - 15%; acetaldehyde dibutyl acetal 2%; cyclohexyl nitrate - 0.5%; and hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 70%.

5

The fuel composition had the following characteristics:

Density at 20°C 0.816 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

10	up to 100°C	0%
	up to 150°C	0%
	up to 200°C	19.5%
	up to 285°C	96.5%
	Flash point	not lower than 50°C
15	Heat of combustion	42.5 MJ/kg
	Thermal stability:	Motor Fuel Composition 12 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -36°C (cloud
20		temperature) to 184°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: D1-
 25 W03-92 according to Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), showed for Motor Fuel Composition 12 a reduction in comparison to the results obtained for 100% Mk1 diesel fuel (SS 15 54 35) of: CO (g/km) of 16%, HC+NO_x (g/km) of 7.5% and particles (g/km) of 18.5%.

30 An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the truck, engine type: VOLVO D7C 290 EUR02 No: 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation, showed for Motor Fuel Composition 12 in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/kW) of 12%, HC+NO_x
 35 (g/kW) of 5.0%, particles (g/kW) of 17.5%.

The power (PkW) of the engine operated on Motor Fuel Composition 12 did not change and the fuel consumption (l/kWh) did not increase in comparison with the results obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

5

Example 13

Motor Fuel Composition 13 demonstrated the possibility of using for operating a standard diesel engine a fuel composition of a hydrocarbon liquid and organic
10 compounds containing bound oxygen which fuel is useful at elevated temperatures and has a flash point not lower than 100°C.

The content by volume of components in Motor Fuel Composition 13 is: 1-octanol -
2%; ethyl oleate - 4%; ethyl caprylate - 2.5%; di-n-amyl ether 4%; di-octyl ether -
15 15%; acetaldehyde dibutyl acetal 2%; cyclohexyl nitrate - 0.5%; and hydrocarbon liquid (gasoil) - 70%.

The fuel composition had the following characteristics:

	Density at 20°C	0.826 g/cm ³
20	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	0%
	up to 150°C	0%
	up to 200°C	18%
25	up to 400°C	98%
	Flash point	not lower than 100°C
	Heat of combustion	42.5 MJ/kg
	Thermal stability:	Motor Fuel Composition 13 was a homogeneous liquid stable at
30		atmospheric pressure over a range of temperature from -20°C (cloud temperature) to 184°C (initial boiling temperature).

35 An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: D1-

W03-92 according to Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC), showed for Motor Fuel Composition 13 a reduction in comparison to the results obtained for 100% Mk1 diesel fuel (SS 15 54 35) of: CO (g/km) of 6.9%, HC+NO_x (g/km) of 2.3% and particles (g/km) of 2.5%.

5

An analysis of the amount of pollutants in the exhaust emissions from the standard diesel engine of the truck, engine type: VOLVO D7C 290 EUR02 No: 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation, showed for Motor Fuel Composition 13 in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/kW) of 0%, HC+NO_x (g/kW) of 0%, particles (g/kW) of 0%.

10

The power (P_{kW}) of the engine operated on Motor Fuel Composition 13 did not change and the fuel consumption (l/kW) did not increase in comparison with the results obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

15

EXAMPLE 14

Motor Fuel Composition 14 demonstrated the possibility of using for operating a diesel engine a fuel composition of a hydrocarbon liquid and of organic compounds containing bound oxygen which is effective at reduced operating temperatures.

20

The content by volume of the components in the fuel composition were: ethanol - 10%; acetaldehyde diethyl acetal - 2.5%; dibutyl ether - 10%; di-isoamyl ether - 6.5%; butyl butyrate - 3.5%; methyltetrahydrofuran - 5%; isoamyl acetate - 2%; isoamyl nitrate - 0.5%; and hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 60%.

25

The fuel composition had the following characteristics:

30

Density at 20°C 0.807 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

up to 100°C 15%

up to 150°C 30 %

up to 200°C 41.5%

35

up to 285°C
Heat of combustion
Thermal stability

96.5%

40.4 MJ/kg

Motor Fuel Composition 14 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -40°C (cloud temperature) to 78°C (initial boiling temperature).

- 5
- 10 An analysis of the amount of pollutants in the exhaust emissions of the standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: DI-W03-92 when testing Motor Fuel Composition 14 according to the Test Type - Modified European Driving Cycle (NEDC UDC + FUDC) FCF OICA (91 /441 /EEC) showed in comparison to the results obtained for 100% Mk1 diesel fuel (SS 15 54 35) the
- 15 reduction in the amounts of: Co (g/kW) of 16.9%, HC+NO_x (g/kw) of 8.8%, and particles (g/kW) of 20.5%.

The use of Motor Fuel Composition 14 for operating a standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings:

20 kW/Nm/rpm = 140/520/1900, showed for measurements over the range 1000 - 2600 rpm, a decrease in the value of power and torque of less than 3.5% in comparison to the values obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35).

25 Example 15

Motor Fuel Composition 15 demonstrated the possibility of using for operating a standard diesel engine and a standard jet engine a fuel composition of a hydrocarbon liquid and of organic compounds containing bound oxygen which is

30 effective at reduced operating temperatures. The hydrocarbon liquid of the Motor Fuel Composition 15 is a mixture of hydrocarbons yielded in processing of gaseous C₂ to C₅ hydrocarbons.

The content by volume of the components in the fuel composition were: ethanol -

35 8%; methanol - 1%; dibutyl ether - 6%; di-isoamyl ether - 8%; butyl butyrate - 3.5%; tetrahydrofurfuryl alcohol - 5%; isoamyl acetate - 2%; isoamyl nitrate - 0.5%;

and hydrocarbon liquid (C₆-C₁₄ hydrocarbons mixture, including not less than 45% of linear hydrocarbons) - 65%.

The fuel composition had the following characteristics:

- | | | |
|----|--|---|
| 5 | Density at 20°C | 0.790 g/cm ³ |
| | Temperature limits of evaporation of the liquid by boiling at atmospheric pressure: | |
| | up to 100°C | 9% |
| | up to 150°C | 17 % |
| 10 | up to 200°C | 50% |
| | up to 280°C | 98% |
| | Heat of combustion | 42.4 MJ/kg |
| 15 | Thermal stability | Motor Fuel Composition 15 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -70°C (cloud temperature) to 64.5°C (initial boiling temperature). |
| 20 | An analysis of the amount of pollutants in the exhaust emissions of the standard diesel engine of the VW GOLF CL DIESEL automobile, engine family: D1-W03-92 when testing Motor Fuel Composition 15 according to the Test Type - Modified European Driving Cycle (NEDC UDC + FUDC) FCF OICA (91 /441 /EEC) showed in comparison to the results obtained for 100% Mk1 diesel fuel (SS 15 54 35) the | |
| 25 | reduction in the amounts of: CO (g/kW) of 26.3%, HC+NO _x (g/kw) of 12.6%, and particles (g/kW) of 31.8%. | |

The use of Motor Fuel Composition 15 for operating a standard diesel truck engine, engine type VOLVO TD61GS No. 0580026, with power and torque settings:

- | | |
|----|--|
| 30 | kW/Nm/rpm = 140/520/1900, showed for measurements over the range 1000 - 2600 rpm, a decrease in the value of power and torque of less than 4.5% in comparison to the values obtained for the same engine operated with 100% Mk1 diesel fuel (SS 15 54 35). |
|----|--|

Similar results for power and exhaust emission changes were obtained when employing the Motor Fuel Composition 15 for operation of the standard aeroplane jet engine.

5

EXAMPLE 16

Motor Fuel Composition 16 demonstrates the possibility of using for operating a diesel engine a fuel composition for a diesel engine of a hydrocarbon liquid and of organic compounds containing bound oxygen also containing 1% of water which
10 does not adversely affect its operating characteristics and does not compromise the stability of the system.

The content by volume of the components in the Motor Fuel Composition 16 is:
water - 1%; ethanol - 9%; di-ethoxypropane - 1%; 1-butanol - 4%; methyl butyrate -
15 4%; 2-ethylhexanol - 20 %; methyltetrahydropyran - 5%; dihexyl ether - 5%;
isopropyl nitrate - 1%; and hydrocarbon liquid (Mk1 diesel fuel SS 15 54 35) - 50%.

The fuel composition had the following characteristics:

	Density at 20°C	0.822 g/cm ³
20	Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:	
	up to 100°C	10%
	up to 150°C	30%
	up to 200°C	50 %
25	up to 285°C	97.5 %
	Heat of combustion	39.4 MJ/kg
	Thermal stability	Motor Fuel Composition 16 was a homogeneous liquid stable at atmospheric pressure over a range of
30		temperature from -36°C (cloud temperature) to 78°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission of the standard
35 diesel engine of the car VW Passat TDI 1.9 model 1997, engine family 2DI-WDE-95,
power kW/rpm = 81/4150 according to the Test Type - Modified European Driving

Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 16, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amount of: CO (g/km) - 22.4 %, HC+NO_x (g/km) - 0 % and particles (g/km) - 6.9 %.

5

An analysis of the amount of pollutants in the exhaust emission of the standard diesel truck engine, engine type: VOLVO D7C 290 EURO2 No. 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation showed for Motor Fuel composition 16 the following results in comparison to 100% Mk1 diesel fuel (SS 15 54 35) - reduction in the amounts of: CO (g/kW) - 6%, HC+NO_x (g/kW) - 0 %, particles (g/kW) - 11 %.

10

The power (P_{kW}) of this diesel truck engine operated on Motor Fuel Composition 16 decreased only 3 % and fuel consumption (l/kw) increased only 2% in comparison with the results obtained for the same engine working on 100% Mk1 diesel fuel (SS 15 54 35).

15

EXAMPLE 17

Motor Fuel Composition 17 demonstrates the possibility of using for operating a standard diesel engine and a standard ship gas-turbine engine a fuel composition of a hydrocarbon liquid and of organic compounds containing bound oxygen also containing 1% of water which does not adversely affect its operating characteristics and does not compromise the stability of the system. Both the hydrocarbon component and the oxygen-containing components of this composition are obtained from vegetation processing.

25

The content by volume of the components in the Motor Fuel Composition 17 is: water - 1%; ethanol - 9%; di-ethoxypropane - 1%; 1-butanol - 4%; methyl butyrate - 4%; 2-ethylhexanol - 12 %; methyl-epoxytallowate - 5%; diisobutyl ketone - 3%; methyltetrahydropyran - 5%; dibutyl ether - 5%; isopropyl nitrate - 1%; and hydrocarbon liquid (synthin derived from synthesis-gas obtained from cellolignine originating from vegetation) - 50%.

30

The fuel composition had the following characteristics:

35

Density at 20°C

0.822 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

	up to 100°C	10%
	up to 150°C	30%
5	up to 200°C	50 %
	up to 400°C	99.5 %

Heat of combustion 39.4 MJ/kg

Thermal stability Motor Fuel Composition 17 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -36°C (cloud temperature) to 78°C (initial boiling temperature).

15 An analysis of the amount of pollutants in the exhaust emission of the standard diesel engine of the car VW Passat TDI 1.9 model 1997, engine family 2DI-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 17, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in
20 the amount of: CO (g/km) - 18.1 %, HC+NO_x (g/km) - 1.2 % and particles (g/km) - 23.4 %.

An analysis of the amount of pollutants in the exhaust emission of the standard diesel truck engine, engine type: VOLVO D7C 290 EUR02 No. 1162 XX, power
25 kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation showed for Motor Fuel composition 17 the following results in comparison to 100% Mk1 diesel fuel (SS 15 54 35) - reduction in the amounts of: CO (g/kW) - 12%, HC+NO_x (g/kW) - 0 %, particles (g/kW) - 13.5 %.

30 The power (PkW) of this diesel truck engine operated on Motor Fuel Composition 17 decreased only 3 % and fuel consumption (l/kw) increased only 2% in comparison with the results obtained for the same engine working on 100% Mk1 diesel fuel (SS 15 54 35).

35 Similar results were obtained when employing the Motor Fuel Composition 17 for operation of the standard ship gas-turbine engine.

EXAMPLE 18

Motor Fuel Composition 18 illustrates a fuel composition for standard diesel and gas-turbine engines formed entirely from organic compounds containing bound oxygen, all of which may be produced from renewable raw material of plant origin. No diesel, kerosene, gasoil or other hydrocarbon fraction was present.

The content by volume of the components in the fuel composition is: ethanol - 1%; 1-butanol - 4%; 2-ethylhexaldehyde - 10 %; acetaldehyde dibutyl acetal - 6%; di-2-ethylhexyl ether - 18%; di-octyl ether - 20%; di-n-amyl ether - 4%; dibutyl ether - 7%; ethyl oleate - 16%; rape seed oil methyl ester - 13.5 %; and di-tert-butyl peroxide - 0.5%.

The fuel composition had the following characteristics:

Density at 20°C	0.830 g/cm ³
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Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

up to 100°C	1%
up to 150°C	12.5 %
up to 200°C	50 %
up to 370°C	95.5%

Heat of combustion	40.6 MJ/kg
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Self-ignition temperature	150°C
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Thermal stability	Motor Fuel Composition 18 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -20°C (cloud temperature) to 78°C (initial boiling temperature).
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An analysis of the amount of pollutants in the exhaust emission of the standard diesel engine of the VW Passat TDI 1.9 model 1997 automobile, engine family 2Dl-WDE-95, power kW/rpm = 81/4150 according to the Test Type -Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 18 showed in comparison with 100% Mk1 diesel fuel (SS 15 54 35), a

reduction in the amount of: CO (g/km) - 5.5 %; HC+NO_x (g/km) - 8.5 % and particles (g/km) - 17.2 %.

5 An analysis of the amount of pollutants in the exhaust emission of the standard diesel truck engine, engine type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 when executing Test Type: ECE R49 A30 Regulation, showed for Motor Fuel Composition 18 the following results in comparison with 100% Mk 1 diesel fuel (SS 15 54 35) - a reduction in the amounts of CO (g/kW) of 0 %; HC+NO_x (g/kW) of 0 %, and particles (g/kW) of 0 %.

10

The power (P_{kW}) of this diesel truck engine operated on Motor Fuel Composition 18 did not change nor did fuel consumption 1/kW change in comparison with the same engine operating on 100% Mk1 diesel fuel (SS 15 54 35). Similar results were obtained when employing the Motor Fuel Composition 18 for operation of the
15 standard ship gas-turbine engine. These results illustrate how the instant invention provides a unique and effective motor fuel composition for diesel engines which does not require a typical heavier hydrocarbon fraction, such as diesel fuel.

Example 19

20

Motor Fuel Composition 19 illustrates a fuel composition formed entirely from oxygen containing compounds, and characterized by good performance properties, including a flash point of 32°C.

25 The content by volume of the components in the fuel composition is: 1-butanol - 5%; 2-ethylhexaldehyde - 8 %; acetaldehyde dibutyl acetal - 6%; di-2-ethylhexyl ether - 18%; di-octyl ether - 20%; di-n-amyl ether - 4%; dibutyl ether - 7%; ethyl oleate - 16%; rape seed oil methyl ester - 12.0 %; and ethylamyl ketone - 2%, 1,2-epoxy-4-epoxycyclohexane - 2%.

30

The fuel composition had the following characteristics:

Density at 20°C 0.831 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

35 up to 100°C 0%
up to 150°C 12.0 %

	up to 200°C	48 %
	up to 285°C	95.5%
	Heat of combustion	40.7 MJ/kg
	Flash point	32°C
5	Self-ignition temperature	150°C
	Thermal stability	Motor Fuel Composition 19 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -30°C (cloud
10		temperature) to 117°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission of the standard diesel engine of the VW Passat TDI 1.9 model 1997 automobile, engine family 2DI-
 15 WDE-95, power kW/rpm = 81/4150 according to the Test Type -Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 19 showed in comparison with 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amount of: CO (g/km) - 7.5 %; HC+NO_x (g/km) - 7.5 % and particles (g/km) - 18.2 %.

20 An analysis of the amount of pollutants in the exhaust emission of the standard diesel truck engine, engine type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 when executing Test Type: ECE R49 A30 Regulation, showed for Motor Fuel Composition 19 the following results in comparison with 100% Mk 1
 25 diesel fuel (SS 15 54 35) - a reduction in the amounts of CO (g/kW) of 8 %; HC+NO_x (g/kW) of 6 %, and particles (g/kW) of 15 %

Similar results were obtained when employing the Motor Fuel Composition 19 for operation of the standard ship gas-turbine engine.

30

EXAMPLE 20

Motor Fuel Composition 20 demonstrates the effects of operating a standard diesel, turbojet and gas-turbine engines with a fuel composition entirely formed of organic
 35 compounds containing bound oxygen, stable over a wide range of ambient temperature and tolerant to presence of water. The fuel composition is

characterised by good performance properties and produces exhaust emissions with a very low content of pollutants.

The content by volume of the components in Motor Fuel Composition 20 is as follows: isoamyl alcohol - 2%; diisoamyl ether -5%; cyclopentanone - 2.5%; cyclohexyl nitrate - 0.5%; 1,2-epoxy-4-epoxy-cyclohexane - 10%; isobornyl methacrylate - 20% and 2,6,8-trimethyl-4-nonanol - 60%.

The fuel composition had the following characteristics:

10

Density at 20°C 0.929 g/cm³

Temperature limits of evaporation by boiling of

The liquid at atmospheric pressure:

15

up to 100°C 0%

up to 150°C 4.5%

up to 200°C 10%

up to 280°C 99.9%

Flash point, not lower than 42°C

Self ignition point 185°C

20

Heat of combustion 39.6 MJ/kg

Thermal stability Motor Fuel Composition 20 is a homogeneous liquid, stable at atmospheric pressure over a range of temperatures from -55°C (cloud temperature) to 131°C (initial boiling temperature).

25

An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 20, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/km) of 62.3%; HC+NO_x (g/km) of 23.5% and particles (g/km) of 54.2%.

35

An analysis of the amount of the pollutants in the exhaust emissions from a standard diesel truck engine, Engine Type: VOLVO D7C 290 EUR02 No. 1162 XX, power kW/rpm = 213/2200 according to the Test Type: ECE R49 A30 Regulation for fuel composition 20, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of: CO (g/kW) of 38.2%; HC+NO_x (g/kW) of 16.8%, and particles (g/kW) of 49.3%.

The power (PkW) of the engine when operating on Motor Fuel Composition 20 increased by 2%, and the fuel consumption (l/kW) decreased by 3%.

Similar results of the reduction of pollutants in the exhaust emissions were obtained when employing the Motor Fuel Composition 20 for operation of the standard ship gas-turbine engine and standard airplane turbojet engine.

The Motor Fuel Composition 20 is immiscible with water and does not adopt almost any amounts of water. When intensively mixing the Motor Fuel Composition 20 by mechanical means with water an emulsion is obtained. After the mixing is stopped the separate layer of water is obtained at the bottom of the tank, and the unaffected motor fuel forms an upper layer in the same tank.

EXAMPLE 21

Motor Fuel Composition 21 demonstrated the possibility to increase stability of the fuel comprising ordinary kerosene containing some amount of water towards influence of lower temperatures.

The content by volume of components in Motor Fuel Composition 21 is: tetrahydrofurfuryl alcohol – 3%; tertbutylperoxyacetate – 2%, hydrocarbon liquid (kerosene with a cloud point of -46°C) – 95%.

The fuel composition had the following characteristics:

Density at 20°C 0.791 g/cm³

Temperature limits of evaporation of the liquid by boiling at atmospheric pressure:

up to 100°C	0%
up to 150°C	0%

up to 200°C	18%
up to 220°C	99.99%
Heat of combustion	43.3 MJ/kg
Thermal stability:	Motor Fuel Composition 21 was a
	homogeneous liquid stable at
	atmospheric pressure over a range
	of temperature from -60°C (cloud
	temperature) to 178°C (initial
	boiling temperature).

An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 21, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/km) of 25%; HC+NO_x (g/km) of 3.5% and particles (g/km) of 30%.

Similar results were obtained when employing the Motor Fuel Composition 21 for operation of the standard airplane turbojet engine.

EXAMPLE 22

Motor Fuel Composition 22 demonstrated the possibility, inter alia, to eliminate a lubrication additive from the composition of hydrocarbon component of the fuel.

The content by volume of components in Motor Fuel Composition 22 is: methylepoxytallowate - 10%; tertbutylhydroperoxide - 0.5%, hydrocarbon liquid (Mk1-type fuel without lubricating additive) - 89.5%.

The fuel composition had the following characteristics:

Density at 20°C	0.818 g/cm ³
-----------------	-------------------------

Temperature limits of evaporation of the

liquid by boiling at atmospheric pressure:

up to 100°C	0%
-------------	----

- | | | |
|----|--------------------|--|
| | up to 150°C | 0% |
| | up to 200°C | 25% |
| | up to 220°C | 95.5% |
| | Heat of combustion | 42.6 MJ/kg |
| 5 | Thermal stability: | Motor Fuel Composition 22 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -30°C (cloud temperature) to 180°C (initial boiling temperature). |
| 10 | | |

- An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 22, showed in comparison to 100% Mk1 diesel fuel (SS 15 54 35), a reduction in the amounts of CO (g/km) of 10%; HC+NO_x (g/km) of 4.5% and particles (g/km) of 16%.
- 20 Similar results were obtained when employing the Motor Fuel Composition 22 for operation of the standard ship gas-turbine engine.

EXAMPLE 23

- 25 Motor Fuel Composition 23 demonstrated the possibility to eliminate an anti-deposit additive from the base diesel fuel.

- The content by volume of components in Motor Fuel Composition 23 is: tetrahydrofurfurylacetate - 10%; tertbutylhydroperoxide - 0.5%, hydrocarbon component (EN590:1993-type fuel without anti-deposit additive) - 89.5%.
- 30

The fuel composition had the following characteristics:

- | | | |
|----|---|-------------------------|
| | Density at 20°C | 0.832 g/cm ³ |
| | Temperature limits of evaporation of the liquid by boiling at atmospheric pressure: | |
| 35 | up to 100°C | 0% |

up to 150°C	0%
up to 200°C	20%
up to 370°C	98.5%

Thermal stability: Motor Fuel Composition 23 was a homogeneous liquid stable at atmospheric pressure over a range of temperature from -30°C (cloud temperature) to 190°C (initial boiling temperature).

An analysis of the amount of pollutants in the exhaust emission from the standard diesel engine of the VW Passat TDI 1.9 automobile, model 1997, Engine Family 2D1-WDE-95, power kW/rpm = 81/4150 according to the Test Type - Modified European Driving Cycle (NEDC UDC + EUDC) ECE OICA (91/441/EEC) for Motor Fuel Composition 23, showed in comparison to 100% diesel fuel (EN590:1993), a reduction in the amounts of CO (g/km) of 12%; HC+NO_x (g/km) of 8% and particles (g/km) of 30%.

Similar results were obtained when employing the Motor Fuel Composition 23 for operation of the standard ship gas-turbine engine.

Each of the Motor Fuel Compositions 1 - 23 was prepared by adding the required amount of components in the same tank at the same temperature in a pre-determined order, starting with the component having (at that temperature) the least density and ending with the component having the highest density, and holding the resulting mixture for at least one hour prior to use.

Example 1 defines a minimum concentration of organic compounds containing bound oxygen in the mixture with a hydrocarbon component, enabling the achievement of the positive effect of this invention.

Examples 2 to 9, 13, 15, and 17 demonstrate the possibility of achieving the positive effect of this invention irrespective of the composition of the hydrocarbon component, i.e., that the invention enables employing various hydrocarbon liquids sold presently on the market.

Examples 4, 5, 8, and 11 demonstrate the possibility of producing the motor fuels for diesel engines using petroleum kerosene fraction, which fuels can also be used for jet engines. Moreover, examples 5, 8 and 15 demonstrate that the fuel of the invention comprising particular hydrocarbon component remains stable under
5 temperatures down to minus 70°C. This property is not demonstrated by any of the fuel formulations revealed by the prior art.

Examples 4, 10, and 11 demonstrate that the present invention enables mixing over extremely wide range of concentrations of organic compounds containing
10 bound oxygen and of a hydrocarbon liquid, wherein no engine modification is required.

Examples 7 and 11 demonstrate the possibility of using hydrocarbons yielded in mineral coal processing as a hydrocarbon component of the motor fuel.
15

Examples 8 and 9 demonstrate the possibility of using methanol and ethanol as a raw material for oxygen-containing compounds required for producing of the novel motor fuel of this invention. Both methanol and ethanol are largely produced in many countries of the world, meaning the novel fuel of this invention has a good
20 raw material situation. Production of the majority of the organic compounds containing bound oxygen needed for production of the fuel of this invention exists in industrial scale. That means that production of the motor fuel of this invention is feasible and can be started up within short period of time.

25 Examples 10 and 11 demonstrate the possibility of using for producing of a motor fuel an organic compound containing bound oxygen, which compound is not thoroughly purified and may contain by-products. It simplifies the production technology and makes those compounds cheaper and more accessible.

30 Examples 12 and 13 demonstrate the possibility of formulating the novel motor fuel stable over wide temperature range from -36°C to +184°C. It should be stressed, that even when brought to reduced or increased beyond the limits temperature, so that phase separation occurs, the fuel of this invention will again form a single, stable and homogeneous phase after it has been allowed to return to temperatures
35 within limits of -36°C and +184°C between the cloud point and starting boiling

point. The examples demonstrate also that the fuels have a high flash point, which makes these fuels safer and simpler in transportation, handling and distribution.

5 Examples 5, 8, 14 and 15 demonstrate the possibility of formulating of the novel motor fuel operating at ambient temperatures below 0°C. Moreover, the hydrocarbon fraction obtained in processing of gaseous C₂-C₅ hydrocarbons can be used for production of the motor fuel of this invention.

10 Examples 16 and 17 demonstrate the possibility to produce the novel motor fuel being tolerant of presence of water. Water content up to 1% vol. does not affect stability of the fuel even at temperatures as low as -36°C. This is extremely important feature of this invention. The prior art does not reveal such a fuel. The motor fuel of this invention does not require for its production thoroughly dehydrated oxygen-containing compounds, making production cheaper and
15 simpler. Moreover, example 17 demonstrates the possibility to employ hydrocarbons yielded in processing of vegetation as a fuel component. The latter feature enables formulating the motor fuel formed entirely by renewable components.

20 Examples 18, 19 and 20 demonstrate the possibility to produce the novel motor fuel for standard engines comprising oxygen-containing compounds only, without using any of hydrocarbons. Such a fuel was never revealed before. Even specially designed ethanol fuel engines require certain content of hydrocarbons in the fuel to improve ignition.

25 Examples 21-23 demonstrate inter alia that the requested combination of four functional groups can be achieved by employing, for example, two compounds.

30 Other variations of the invention are included as will be clear to those of ordinary skill in this art, such as, for example, to use only three compounds. The invention is not to be limited except as set forth in the following claims:

CLAIMS

1. A stable motor fuel composition for diesel, gas-turbine and jet engines, including standard engines having reduced emission of pollutants comprising:

- 5 (a) an oxygen-containing organic compound component exhibiting at least four different oxygen-containing functional groups selected from alcohol, ether, aldehyde, ketone, ester, inorganic ester, acetal, epoxide, and peroxide groups, wherein said at least four groups is contributed to by any combination of two or more different oxygen-containing compounds, each of which contains at
10 least one of said groups; and, optionally,
 (b) a hydrocarbon component.

2. The motor fuel composition of claim 1, wherein the oxygen-containing component is comprised of at least four types of organic compounds differing in
15 functional groups containing bound oxygen, which compounds preferably exhibit one or two functional groups each, and more preferably one functional group each.

3. The motor fuel composition of any of claim 1 or 2, wherein one or more different compounds can exhibit the same functional group(s).

20 4. The motor fuel composition of any of the preceding claims, wherein the oxygen-containing organic compounds are linear or sparsely branched.

5. The motor fuel composition of any of the preceding claims, wherein the oxygen-
25 containing organic compound component is present in amounts from about 5% to 100% based on the total volume of the motor fuel composition and the hydrocarbon component is present in amounts from 0 to about 95%, based on the total volume of the motor fuel composition.

30 6. The motor fuel composition of any of the preceding claims, wherein the oxygen-containing component of the motor fuel of the invention preferably includes (i) alcohols, (ii) ethers, (iii) organic esters and (iv) at least one of aldehyde, ketone, inorganic ester, acetal, epoxide, and peroxide, and preferably all mentioned in (iv).

35 7. The motor fuel composition of any of the preceding claims, having at least one, suitably at least two, and preferably all of the following properties (i) to (vii):

- (i) density at 20°C of not less than 0.775 g/cm³;
- (ii) cloud temperature is not higher than 0°C at atmospheric pressure;
- (iii) stable at atmospheric pressure from a cloud temperature of 0°C to an initial boiling point of 50°C;

5 (iv) amounts of liquid evaporated by boiling at atmospheric pressure include:

- not more than 25% of the total volume of the motor fuel composition distills at temperatures no higher than 100°C;
- not more than 35 % of the total volume of the motor fuel composition distills at temperatures no higher than 150°C;
- not more than 50% of the total volume of motor fuel composition distills at temperatures no higher than 200°C ;
- not less than 98% of the total volume of the motor fuel composition distills at temperatures no higher than 400°C, suitably no higher than 370°C; and preferably no higher than 280°C;

10
15 (v) heat of combustion on oxidation by oxygen of not less than 39 MJ/kg;

- (vi) self-ignition temperature from 150°C to 300°C; and
- (vii) ability to accommodate at least 1% water by volume.

20

8. The motor fuel composition of any of the previous claims, wherein at least one of methanol or ethanol, and optionally, by-products of from the production of said methanol or ethanol is present in the oxygen-containing compound component.

25

9. The motor fuel composition of any of the previous claims, wherein the oxygen-containing compound component contains contaminants co-produced or present during production of said oxygen-containing compound component.

30

10. The motor fuel composition of any of the previous claims, which is stable at atmospheric pressure over a temperature range from a cloud temperature of -35°C to an initial boiling temperature of 180°C.

35

11. The motor fuel composition of any of the previous claims, which is stable over a range of temperatures from a cloud point of -50°C to an initial boiling point of 50°C.

12. The motor fuel composition of any of the previous claims, including water in amounts of at least about 1% by volume based on the total volume of the motor fuel composition.

5

13. The motor fuel composition of any of the previous claims, wherein the oxygen-containing organic compound component is formed from a renewable plant resource.

10

14. The motor fuel composition of any of the previous claims, wherein the hydrocarbon component is a diesel fraction, or a mixture of a diesel fraction and a hydrocarbon fraction lighter than the diesel fraction.

15

15. The motor fuel composition of any of the previous claims, wherein the hydrocarbon component is a gasoil fraction or a mixture of a gasoil fraction and a hydrocarbon fraction lighter than gasoil fraction.

20

16. The motor fuel composition of any of the claims 1 - 13, wherein the hydrocarbon component is obtained from renewable resources, including turpentine, rosin or other oxygen-containing compounds.

25

17. The motor fuel composition of claim 1 - 13, wherein the hydrocarbon component is obtained from synthesis-gas, optionally obtained from biomass; or from a C₁-C₄ gas-containing fraction; or from pyrolysis of carbonaceous materials, optionally, comprising biomass, or a mixture thereof.

18. The motor fuel composition of claims 1-17, wherein the oxygen containing components provide the required lubrication properties of the motor fuel.

30

19. The motor fuel composition of claims 1-18, wherein the oxygen containing components provide reduction of deposit in the combustion chamber.

35

20. Method of preparing the motor fuel composition of any of the preceding claims, comprising successively introducing into a fuel reservoir at the same temperature the components of the motor fuel composition, beginning with the component

having the least density at that temperature and terminating with the component having the highest density at that temperature.

AMENDED CLAIMS

[received by the International Bureau on 16 February 2001 (16.02.01);
original claims 1-20 replaced by amended claims 1-20 (4 pages)]

1. A stable homogeneous motor fuel composition for standard diesel, gas-turbine and jet engines, having improved water tolerance and resulting in reduced emission of pollutants, comprising, by volume:

(a) from 5 % to 100 % of a component consisting of oxygen-containing organic compounds altogether exhibiting at least four different oxygen-containing functional groups selected from alcohol, ether, aldehyde, ketone, ester, inorganic ester, acetal, epoxide, and peroxide groups, wherein said at least four groups is contributed to by any combination of two or more different oxygen-containing compounds, each of which contains at least one of said groups, said compounds being selected from:

C₁-C₁₀ and/or C₁₂ alcohols,

aldehydes of the general formula $\text{R}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{H}$, wherein R is a C₁-C₈.

hydrocarbon residue,

ketones of the general formula $\text{R}-\overset{\text{O}}{\underset{\parallel}{\text{C}}}-\text{R}_1$, wherein R and R₁ each are a C₁ - C₈ hydrocarbon residue, the same or different or, together, form a cyclic ring, mono-, di- and/or cycloethers,

C₁-C₈ alkyl esters of C₁-C₂₂ saturated or unsaturated fatty acids,

acetals having the general formula RCH(OR')₂ wherein R is hydrogen or hydrocarbyl,

organic esters of inorganic acids,

organic peroxides of the formula R-O-O-R' where R and R' are each the same or different,

organic epoxides having the general formula $\text{R}-\overset{\text{O}}{\triangle}-\text{R}'$, where R and R' are the same or different and are C₁ - C₁₂ hydrocarbyls; and,

(b) 0 to 95 % of a hydrocarbon component,

said motor fuel composition having at least one, suitably at least two, and preferably all of the following properties (i) to (vii):

(i) density at 20°C of not less than 0.775 g/cm³;

(ii) cloud temperature is not higher than 0°C at atmospheric pressure;

(iii) stable at atmospheric pressure from a cloud temperature not higher than 0°C to an initial boiling point not lower than 50°C;

(iv) amounts of liquid evaporated by boiling at atmospheric pressure

include:

- not more than 25% of the total volume of the motor fuel composition distills at temperatures no higher than 100°C;

- not more than 35 % of the total volume .of the motor fuel composition distills at temperatures no higher than 150°C;

- not more than 50% of the total volume of motor fuel composition distills at temperatures no higher than 200°C ;

- not less than 98% of the total volume of the motor fuel composition distills at temperatures no higher than 400°C, suitably no higher than 370°C; and preferably no higher than 280°C;

(v) heat of combustion on oxidation by oxygen of not less than

39 MJ/kg;

(vi) self-ignition temperature from 150°C to 300°C; and

(vii) ability to accommodate at least 1% water by volume.

2. The motor fuel composition of claim 1, wherein the minimum amount of any of the at least four functional groups, calculated as the total volume of the compound(s) exhibiting the particular group, should not be lower than 0.1%, suitably not lower than 0.5%, and preferably not lower than 1% of the total volume of the fuel composition.

3. The motor fuel composition of claim 1 or 2, wherein the oxygen-containing component is comprised of at least four types of organic compounds differing in functional groups containing bound oxygen, which compounds preferably exhibit one or two functional groups each, and more preferably one functional group each.

4. The motor fuel composition of any of the preceding claims, wherein one or more different compounds can exhibit the same functional group(s).

5. The motor fuel composition of any of the preceding claims, wherein the oxygen-containing organic compounds are linear or sparsely branched.

6. The motor fuel composition of any of the preceding claims, wherein the oxygen-containing component of the motor fuel of the invention preferably includes (i) alcohols, (ii) ethers, (iii) organic esters and (iv) at least one of aldehyde, ketone, inorganic ester, acetal, epoxide, and peroxide, and preferably all mentioned in (iv).

7. The motor fuel composition of any of the previous claims, wherein at least one of methanol or ethanol, and optionally, by-products of from the production of said methanol or ethanol is present in the oxygen-containing compound component.

8. The motor fuel composition of any of the previous claims, wherein the oxygen-containing compound component contains contaminants co-produced or present during production of said oxygen-containing compound component.

9. The motor fuel composition of any of the previous claims, which is stable at atmospheric pressure over a temperature range from a cloud temperature not higher than -35°C to an initial boiling temperature not lower than 180°C .

10. The motor fuel composition of any of the previous claims, which is stable over a range of temperatures from a cloud point not higher than -50°C to an initial boiling point not lower than 50°C .

11. The motor fuel composition of any of the previous claims, including water in amounts of at least about 1% by volume based on the total volume of the motor fuel composition.

12. The motor fuel composition of any of the previous claims, wherein the oxygen-containing organic compound component is formed from a renewable plant resource.

13. The motor fuel composition of any of the previous claims, wherein the hydrocarbon component is a diesel fraction, or a mixture of a diesel fraction and a hydrocarbon fraction lighter than the diesel fraction.

14. The motor fuel composition of any of the previous claims, wherein the hydrocarbon component is a gasoil fraction or a mixture of a gasoil fraction and a hydrocarbon fraction lighter than gasoil fraction.

15. The motor fuel composition of any of the claims 1 - 12, wherein the hydrocarbon component is obtained from renewable resources, including turpentine, rosin or other oxygen-containing compounds.

16. The motor fuel composition of claim 1 - 12, wherein the hydrocarbon component is obtained from synthesis-gas, optionally obtained from biomass; or from a C₁-C₄ gas-containing fraction; or from pyrolysis of carbonaceous materials, optionally, comprising biomass, or a mixture thereof.

17. The motor fuel composition of claims 1 - 16, wherein the oxygen containing components provide the required lubrication properties of the motor fuel.

18. The motor fuel composition of claims 1 - 17, wherein the oxygen containing components provide reduction of deposit in the combustion chamber.

19. The motor fuel composition of any of the claims 1 - 6 and 8 - 18, exhibiting a flash point of not lower than 50 °C.

20. Method of preparing the motor fuel composition of any of the preceding claims, comprising successively introducing into a fuel reservoir at the same temperature the components of the motor fuel composition, beginning with the component having the least density at that temperature and terminating with the component having the highest density at that temperature.

Statement under A. 19(1) PCT

In the attached new set of claims originally filed claims 5 and 7 have been incorporated into the new claim 1, and old claims 5 and 7 cancelled.

Component (a) has been restricted by means of specifying the numbers of carbon atoms in the respective different compounds (from p. 11 and 12 of the description as filed).

The preamble of claim 1 has been amended in order to more clearly point out the aim of the present invention.

A new claim 2 has been inserted having support in the description on p. 13, lines 4 to 7.

Finally a new claim 19 has been inserted having support in Example 12.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 00/01717

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: C10L 1/02, C10L 1/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: C10L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0121089 A2 (UNION RHEINISCHE BRAUNKOHLN KRAFTSTOFF AKTIENGESELLSCHAFT), 10 October 1984 (10.10.84), see page 4 --	1-20
X	WO 9502654 A1 (VICTORIAN CHEMICAL INTERNATIONAL PTY LTD), 26 January 1995 (26.01.95), see composition 24, 9 --	1-20
X	US 4356001 A (WILLIAM M. SWEENEY ET AL), 26 October 1982 (26.10.82) --	1-20
X	FR 2498622 A1 (INSTITUT FRANCAIS DU PETROLE), 30 July 1982 (30.07.82) --	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

12 January 2001

Date of mailing of the international search report

16 -01- 2001

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE00/01717**Box I** Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: **1-19**
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Present claims 1-19 relate to an extremely large number of possible fuel compositions. Therefore, the search has been mainly limited to such examples and compositions mentioned in the description.
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT
Information on patent family members

04/12/00

International application No.
PCT/SE 00/01717

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
EP	0121089	A2	10/10/84	SE	0121089	T3	
				AT	43625	T	15/06/89
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				CA	2167294	A	26/01/95
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				SE	0708808	T3	
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				DE	3150988	A,C	05/08/82
				DE	3150989	A,C	05/08/82
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				GB	2090612	A,B	14/07/82
				GB	2090613	A,B	14/07/82
				OA	6975	A	31/07/83
				OA	6976	A	31/07/83
				OA	6982	A	31/08/83
